METHOD FOR IMPROVING DENT-RESISTANCE OF A STEEL PLATE

CROSS-REFERENCE TO RELATED APPLICATIONS

[001] This application claims priority of Korean Application No. 10-2003-0049099, filed on July 18, 2003, the disclosure of which is incorporated fully herein by reference.

FIELD OF THE INVENTION

[002] The present invention relates to a method for improving dent-resistance of a steel plate by prestraining the steel plate through a skin pass mill process where a certain reduction rate is provided.

BACKGROUND OF THE INVENTION

[003] In general, an outer panel of a vehicle requires improved processability for fabricating a certain part into a desired shape after a press forming process. the outer panel may also require an improved dent-resistant property. An outer panel of a vehicle body is generally made of a cold-rolled steel plate having a high elongation rate and a large plastic deformation rate. A high yield strength as well as excellent processability for fabricating an outer panel such as a door, a hood, a panel, etc. may be desirable. By contrast, if yield strength of a steel plate is low, the steel plate can be easily dented even when slightly pressed by hands or other external forces.

[004] A dent may indicate that a certain defect occurred on a surface of an outer panel due to the above reasons. The property of limiting a dent is referred to as dent-resistance. A steel plate should generally have high yield strength to enhance dent resistance of an outer panel of a vehicle. However, when yield strength of a steel plate is too high, a process defect may occur during a forming process before the steel plate is formed. In addition, a spring-back phenomenon may occur after the forming process. It may therefore become challenging to fabricate a certain part in a desired shape.

[005] Methods for enhancing yield strength of an outer panel of a vehicle body, to enhance dent-resistance of an outer panel of a vehicle body are known from the related art. For instance, methods such as a method of improving the amount of components of a steel plate, a method of using a combined material fabricated by mixing heterogeneous materials with each other, and a method achieved by combining both the above methods are known.

[006] For example, according to the Japanese patent laid-open No. Hei 8-35035, there is provided a dual-skin steel plate formed of an inner steel panel and a surface steel plate with a different amount of steel for enhancing dent-resistance, a fatigue property, a surface deformation resistance and a processability. In another example, according to the Japanese patent No. Hei 5-111976, there is provided a core plate of aluminum or an aluminum alloy. A construction for enhancing the entire dent-resistance is provided by conjugating a low carbon steel plate to both surfaces of the core plate. In yet another example, according to the Japanese patent No. Sho 58-37150, a steel having a ferrite-martensite is provided on a surface of the construction, and a cold-rolled steel plate having a soft steel tissue is provided in an inner side of the construction.

[007] Nevertheless, in the above methods, a surface defect called as a stretcher strain may occur on a surface of a steel plate, and reduce the ability to accurately control the amount of components. Moreover, the processability by the products is not uniform.

SUMMARY OF THE INVENTION

[008] Embodiments of the present invention relate to a method for improving the dent-resistance of a steel plate. It may be possible to enhance yield strength of a steel plate and obtain an excellent forming property in such a manner that a steel plate is pre-strained by providing a certain reduction rate during a skin pass mill process performed for a density and shape modification of the steel plate.

[009] In one embodiment of the present invention, an outer panel comprising steel material such as a roof, a door, a hood, etc., having an excellent processability and a dent-resistant property is fabricated using the method of the present invention. Increasing strength of an outer panel of a vehicle may allow for decreasing the thickness of the material.

[0010] In another embodiment of the present invention, yield strength of a steel plate may be enhanced based on an increase in the degree of work-hardening by pre-straining the steel plate in a state of one axis tensile prior to a press process.

[0011] In yet another embodiment, a method for pre-straining is achieved based on a skin pass mill process in accordance with a reduction rate of 1.8%~2.0% during fabrication of a cold-rolled steel plate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The aforementioned aspects and other features of the present invention will be explained in the following description, taken in conjunction with the accompanying drawings, wherein:

[0013] FIG. 1 is a graph of an increase of tensile strength based on an increase of a reduction rate during a skin pass mill process for dent-resistance enhancing method according to the present invention;

[0014] FIG. 2 is a graph of a forming limit showing an increase in forming property after an extension based on a method for enhancing dent-resistant property according to the present invention; and

[0015] FIG. 3 is a graph illustrating a relationship between a pre-strain ratio and a FLD in a method for enhancing dent-resistant property according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] Hereinafter, such embodiments of the present invention are described in detail with reference to the accompanying drawings.

[0017] In the methods according to the present invention, there are provided a few methods such as a method of applying a pre-strain during a skin pass mill process for enhancing a forming property and a dent-resistant property of parts based on yield strength enhancement of a steel plate, and a method of enhancing a reduction rate during a skin pass mill process.

[0018] In order to enhance a dent-resistant property of a steel plate with a mechanical process, it may be required to increase work-hardening, namely, yield strength (YP), by providing a material with a pre-straining process before a press process is performed.

[0019] Applying a pre-strain to a material is directed to deforming the material before a press process is performed. The pre-straining process may be performed within a range of 5%.

[0020] Pre-straining processes are generally performed in a deep drawing state or one axis extending state for preventing any changes in thickness of a material to enhance a forming property and strength. The pre-straining process may be performed by a method of providing one axis tensile force to a material before a press process is

performed, but it is not very feasible to apply it to the practical field due to many obstacles in constructing the required facilities.

[0021] In the present invention, a method for providing a pre-straining process to a material before a press process is performed, there is provided a method of adjusting a reduction rate during a skin pass mill process. In this manner, it may be possible to apply the method to existing production facilities without additional facilities and any difficulties in the facilities or construction.

[0022] A skin pass mill process is directed to a process last performed during a cold-rolled steel plate fabrication and is capable of adjusting a density of a steel plate and correcting a shape of the same.

[0023] The reduction rate of the skin pass mill process may be limited within a range of 0.5%~1.2% to provide a permissible range of a product thickness and density.

[0024] It is known that the mechanical property of material may be enhanced when a reduction rate is increased, but the above principle may not be applied in the field due to a decrease of elongations and the above-described problems. So far, the researches concerning the above problems have not been successful, so that systematic researches have not been performed yet.

[0025] FIG. 1 is a graph showing an increase of tensile strength based on an increase in reduction rate during a skin pass mill process for a dent-resistance enhancing method according to the present invention.

[0026] According to one result, it was known that a tensile strength was increased by 1.3kgf/mm^2 when an elongation of a skin pass mill was increased by 0.4%.

[0027] Despite the above test result, it was impossible to increase reduction rate of the skin pass mill above a certain range because increasing the tensile strength may decrease the elongation in a tensile test resulting in a decrease in a forming property.

[0028] As shown in FIG. 2, however, even though the elongation may be decreased after the pre-straining process on one axis extension, the forming property may be increased. FIG. 2 is a forming limit diagram showing a forming property after one axis extension.

[0029] In one embodiment of the present invention, in order to measure the changes of material characteristics while increasing the reduction rate during the skin pass mill, the material processed through a conventional skin pass mill process was applied with a reduction rate of 0.5%, 1%, and the result of the tests were compared.

Table 1 shows the changes in the mechanical characteristics of SPRC 340-BH by the pre-straining process.

[0030] Table 1

PreStrain (%)	Yield strength (kgf/mm^2)	Tensile strength (kgf/mm^2)	Uniform El (%)	Elongation (%)	r-value	n-value	Tensional/yield strength ratio (%)
0	23.63	20.54	20.54	39.38	1.73	0.19	64.5
0.5	26.31	18.35	18.35	37.63	1.78	0.17	71.2
1	27.46	17.84	17.84	37.45	1.73	0.16	75.9

[0031] According to the data presented in Table 1, when the reduction rate was increased by 0.5%, the elongation was decreased about 1.8%, and the tensile/yield strengths rate was increased about 7%. When the reduction rate was increased by 1%, the elongation was decreased by 1.9% as compared with the conventional material, and the tensile/yield strengths ratio was increased by 11%. As a result of the above test, it is known that the tensile/yield strengths ratio may exceed 70% before the parts are press-processed.

[0032] The results of the forming properties in other stress states after the pre-strain is performed are shown as a forming limit diagram. Since the pre-strain of the increase of the reduction rate is one axis extension, it may be expected that the forming property is increased despite the decrease of the elongation.

[0033] In the present invention, the pre-straining process may be performed using a conventional skin pass mill process, and the reduction rate may be maintained within a range of 1.8~2.0% higher than the conventional limited range of 0.5~1.2%. Therefore, it may be possible to enhance the dent-resistant property of an outer panel of a vehicle, and enhance the press forming property.

[0034] According to a result of the tests, when the reduction rate was increased by 1.8~2.0%, the yield strength of the SPRC 340-BH (material for FLD test) was increased $27kgf/mm^2$. Additionally, about 4~5(kgf/mm^2) of the yield strength was increased with respect to a reduction rate of 1%. Moreover, an additional increase by 2~3 kgf/mm^2 was obtained when Bake-hardening steel capable of increasing the yield strength was additionally used after the press process using the heat treatment effect during the coating process.

[0035] An adjustment of these exemplary values may be required because high yield strength before the press process may cause a deformation in an outer panel of a vehicle in accordance with the material. Therefore, in order to fabricate a product having an excellent processability and dent-resistant property, it may be needed to systemize the

physical characteristics of each material for thereby properly adjusting the above two effects.

[0036] FIG. 3 is a graph showing a relationship between a pre-strain ratio and FLD in a dent-resistant property enhancing method according to the present invention.

[0037] As shown in Figure 3, the FLD was obtained by applying different pre-strains. Results of the tensile test following the pre-straining process, indicated that the elongation was slightly decreased by about 3%, but results of the FLD test showed a forming limit in different deformation states, where the elongation was slightly increased from 1%.

[0038] Generally, it is acknowledged that if forming property is not decreased after pre-straining process, it is successful. As shown in the above tests, the forming property was slightly increased after one axis extension.

[0039] As described above, the present invention provides a method capable of enhancing yield strength of a steel plate in such a manner that a pre-straining process may be performed with respect to a steel plate based on a skin pass mill under a condition that a certain reduction rate is maintained. Therefore, it is possible to enhance a dent-resistant property of an outer panel of a vehicle, and enhance a forming property during a press process of a steel plate.